

What is claimed is:

- 1 1. A machine implemented method for replicating content of a source disk to at least  
2 one of a plurality of target disks, comprising:  
3 establishing at most one producer process for reading content of a source into a  
4 buffer;  
5 establishing at least one consumer process for reading content from the buffer and  
6 writing the content to a target; and  
7 coordinating concurrent synchronous copy operations by the producer process from  
8 the source to the buffer and by the at least one consumer process from the  
9 buffer to the target.
- 1 2. The method of claim 1, wherein coordinating concurrent synchronous copy  
2 operations by the producer process from the source to the buffer and by the at least  
3 one consumer process from the buffer to the target comprises semaphore based  
4 synchronization of multiple concurrent copy operations into and from a shared  
5 memory.
- 1 3. The method of claim 1, wherein establishing at least one consumer process for  
2 reading content from the buffer and writing the content to a target comprises  
3 establishing at least one subsequent consumer process for reading data from the  
4 buffer and writing the content to a target, wherein the subsequent consumer process  
5 commences reading data from the shared buffer at a point where the producer process  
6 has last written data.

- 1 4. The method of claim 3, wherein coordinating concurrent synchronous copy  
2 operations by the producer process from the source to the buffer and by the at least  
3 one consumer process from the buffer to the target comprises blocking the producer  
4 process from overwriting a portion of data in the shared buffer until each of the  
5 consumer processes has read the portion of data.
- 1 5. The method of claim 4, thereby enabling the producer to process to make only one  
2 pass through the content of the source.
- 1 6. The method of claim 3, wherein coordinating concurrent synchronous copy  
2 operations by the producer process from the source to the buffer and by the at least  
3 one consumer process from the buffer to the target comprises blocking each of the  
4 consumer processes from reading content of the buffer until the producer process has  
5 written a portion of data that the consumer process has not yet read.
- 1 7. The method of claim 6, thereby enabling pacing of the producer process by a  
2 consumer process.
- 1 8. The method of claim 3, wherein establishing at least one subsequent consumer  
2 process for reading data from the buffer and writing the content to a target comprises  
3 detecting when a consumer process has reached the end of a disk image in the shared  
4 buffer and cycling the consumer process to continue reading content stored in the

5 buffer, which content was read from the source and stored in the buffer by the  
6 producer process.

1 9. The method of claim 8, wherein establishing at least one subsequent consumer  
2 process for reading data from the buffer and writing the content to a target further  
3 comprises detecting when a consumer process has read a complete disk image from  
4 the shared buffer.

1 10. The method of claim 1, wherein a process determines whether the process is a  
2 producer process or a consumer process by detecting the presence of other disk  
3 replication processes in the system.

1 11. A computer-readable medium carrying one or more sequences of instructions for  
2 replicating a disk, which instructions, when executed by one or more processors,  
3 cause the one or more processors to carry out the steps of:  
4 establishing at most one producer process for reading content of a source into a  
5 buffer;  
6 establishing at least one consumer process for reading content from the buffer and  
7 writing the content to a target; and  
8 coordinating concurrent synchronous copy operations by the producer process from  
9 the source to the buffer and by the at least one consumer process from the  
10 buffer to the target.

1 12. The computer-readable medium of claim 11, wherein the instructions for carrying out  
2 the step of coordinating concurrent synchronous copy operations by the producer  
3 process from the source to the buffer and by the at least one consumer process from  
4 the buffer to the target comprises the instructions for carrying out a step of  
5 synchronizing using semaphores multiple concurrent copy operations into and from a  
6 shared memory.

1 13. The computer-readable medium of claim 11, wherein the instructions for carrying out  
2 the step of establishing at least one consumer process for reading content from the  
3 buffer and writing the content to a target comprises the instructions for carrying out a  
4 step of establishing at least one subsequent consumer process for reading data from  
5 the buffer and writing the content to a target, wherein the subsequent consumer  
6 process commences reading data from the shared buffer at a point where the producer  
7 process has last written data.

1 14. The computer-readable medium of claim 13, wherein the instructions for carrying out  
2 the step of coordinating concurrent synchronous copy operations by the producer  
3 process from the source to the buffer and by the at least one consumer process from  
4 the buffer to the target comprises the instructions for carrying out a step of blocking  
5 the producer process from overwriting a portion of data in the shared buffer until each  
6 of the consumer processes has read the portion of data.

1 15. The computer-readable medium of claim 14, thereby enabling the producer to process  
2 to make only one pass through the content of the source.

1 16. The computer-readable medium of claim 13, wherein the instructions for carrying out  
2 the step of coordinating concurrent synchronous copy operations by the producer  
3 process from the source to the buffer and by the at least one consumer process from  
4 the buffer to the target comprises the instructions for carrying out a step of blocking  
5 each of the consumer processes from reading content of the buffer until the producer  
6 process has written a portion of data that the consumer process has not yet read.

1 17. The computer-readable medium of claim 16, thereby enabling pacing of the producer  
2 process by a consumer process.

1 18. The computer-readable medium of claim 13, wherein the instructions for carrying out  
2 the step of establishing at least one subsequent consumer process for reading data  
3 from the buffer and writing the content to a target comprises the instructions for  
4 carrying out a step of detecting when a consumer process has reached the end of a  
5 disk image in the shared buffer and cycling the consumer process to continue reading  
6 content stored in the buffer, which content was read from the source and stored in the  
7 buffer by the producer process.

1 19. The computer-readable medium of claim 18, wherein the instructions for carrying out  
2 the step of establishing at least one subsequent consumer process for reading data  
3 from the buffer and writing the content to a target further comprises the instructions  
4 for carrying out a step of detecting when a consumer process has read a complete disk  
5 image from the shared buffer.

1     20.     The computer-readable medium of claim 11, wherein a process determines whether  
2             the process is a producer process or a consumer process by execution of instructions  
3             for carrying out a step of detecting the presence of other disk replication processes in  
4             the system.

1     21.     An apparatus comprising:  
2             means for establishing at most one producer process for reading content of a source  
3                         into a buffer;  
4             means for establishing at least one consumer process for reading content from the  
5                         buffer and writing the content to a target; and  
6             means for coordinating concurrent synchronous copy operations by the producer  
7                         process from the source to the buffer and by the at least one consumer process  
8                         from the buffer to the target.

1     22.     An apparatus comprising:  
2             a producer engine operative to copy data from a source to a sharable work area;  
3             at least one consumer engine operative to copy data from the sharable work area to a  
4                         destination; and  
5             a coordination engine operative to coordinate the producer engine, at least one  
6                         consumer engine and the sharable work area;  
7             thereby providing a single pass read of data from the source to be replicated to one or  
8                         more destinations by individual instances of consumer engines having non-  
9                         concurrent start times.

1    23.    A system, comprising:  
2           a first computer, operatively configured to execute program instructions for  
3           performing the steps of:  
4           establishing a producer process for reading content of a source into a buffer;  
5           establishing at least one consumer process for reading content from the buffer  
6           and writing the content to a target; and  
7           coordinating concurrent synchronous copy operations by the producer process  
8           from the source to the buffer and by the at least one consumer process  
9           from the buffer to the target; and  
10          a second computer, operative to execute program instructions for performing the steps  
11          of:  
12          monitoring the first computer; and  
13          a network interconnecting the first computer and the second computer.

1    24.    A system, comprising:  
2           a first network node;  
3           a second network node; and  
4           a network connecting the first node and the second node, wherein:  
5           the first network node comprises program instructions for causing one or more  
6           processors to perform the step of:  
7           establishing a producer process for reading content of a source into a buffer;  
8           and

9           the second network node comprises program instructions for causing one or more  
10           processors to perform the step of:  
11           establishing at least one consumer process for reading content from the buffer  
12           and writing the content to a target; and  
13           wherein at least one of the first node and the second node further comprises program  
14           instructions for causing one or more processors to perform the step of:  
15           coordinating concurrent synchronous copy operations by the producer process  
16           from the source to the buffer and by the at least one consumer process  
17           from the buffer to the target.